Petroleum Science and Technology 2018 vol.36 N18, pages 1439-1445

The catalytic effects of carbonate minerals on characteristics of heavy oil in hydrothermal reactions

Nasyrova Z., Aliev A., Petrov S., Safiulina A., Mukhamatdinov I.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2018, © 2018 Taylor & Francis Group, LLC. Hydrothermal influences on heavy oil were simulated in laboratory conditions. The experimental model was composed of oil, calcite, dolomite, and manganese oxide. Oil to dominant mineral ratio was 1:1, where the content of manganese oxide was 5%. The hydrothermal reactions were carried out under the reservoir temperatures of 250–300°C and a pressure of 1–2 MPa. As a result of treatment, aromaticity of oil increased, while H:C ratio decreased from 1.92 to 1.61. The structures of newly formed light fractions were characterized by low molecular aromatic compounds, which were the destruction products of resins. The treatment provided removal of nitrogen and sulfur from crude oil, hence, decreasing the viscosity of products. The genotype of crude oil did not change. The quantitative changes in the ratio of isoprenoid alkanes to the linear ones were evaluated via geochemical coefficients of group composition.

http://dx.doi.org/10.1080/10916466.2018.1484767

Keywords

calcite, dispersion, dolomite, geochemical coefficients, group composition, heavy oil, hydrothermal influences, rheology

References

[1] Ahmadi, M. A., and S. R., Shadizadeh. 2013. Experimental investigation of adsorption of a new nonionic surfactant on carbonate minerals. Fuel 104:462–7. doi:10.1016/J.FUEL.2012.07.039.

[2] Bera, A., and T., Babadagli. 2015. Status of electromagnetic heating for enhanced heavy oil/bitumen recovery and future prospects: A review. Applied Energy 151:206–26. doi:10.1016/J.APENERGY.2015.04.031.

[3] Castorena-Cortés, G., I., Zapata-Peñasco, T., Roldán-Carrillo, J., Reyes-Avila, M., Mayol-Castillo, S., Román-Vargas, and P., Olguín-Lora. 2012. Evaluation of indigenous anaerobic microorganisms from Mexican carbonate reservoirs with potential MEOR application. Journal of Petroleum Science and Engineering 81:86–93. doi:10.1016/J.PETROL.2011.12.010.

[4] Chu, Y., C., Fan, Q., Zhang, C., Zan, D., Ma, H., Jiang, Y., Wang, and F., Wei. 2014. The oxidation of heavy oil to enhance oil recovery: The numerical model and the criteria to describe the low and high temperature oxidation. Chemical Engineering Journal 248:422–9. doi:10.1016/J.CEJ.2014.03.036.

[5] Feoktistov, D. A., G. P., Kayukova, A. V., Vakhin, and S. A., Sitnov. 2018. Catalytic aquathermolysis of high-viscosity oil using iron, cobalt, and copper tallates. Chemistry and Technology of Fuels and Oils 53 (6): 905–12. doi:10.1007/s10553-018-0880-4.

[6] Galukhin, A., M. A., Khelkhal, A., Gerasimov, T., Biktagirov, M., Gafurov, A., Rodionov, and S., Orlinskii. 2016. Mn-catalyzed oxidation of heavy oil in porous media: Kinetics and some aspects of the mechanism. Energy & Fuels 30 (9):7731–7. doi:10.1021/acs.energyfuels.6b01234.

[7] Hou, J., C., Li, H., Gao, M., Chen, W., Huang, Y., Chen, and C., Zhou. 2017. Recyclable oleic acid modified magnetic NiFe2O4 nanoparticles for catalytic aquathermolysis of liaohe heavy oil. Fuel 200:193–8. doi:10.1016/J.FUEL.2017.03.005.

[8] Kapadia, P. R., M. S., Kallos, and I. D., Gates. 2015. A review of pyrolysis, aquathermolysis, and oxidation of athabasca bitumen. Fuel Processing Technology 131:270–89. doi:10.1016/J.FUPROC.2014.11.027.

[9] Kayukova, G. P., D. A., Feoktistov, A. N., Mikhailova, I. P., Kosachev, R. Z., Musin, and A. V., Vakhin. 2018. Influence of the nature of metals and modifying additives on changes in the structure of heavy oil in a catalytic aquathermolysis system. Petroleum Chemistry 58 (3):190–6. Pleiades Publishing: doi:10.1134/S0965544118030118.

[10] Kayukova, G. P., L. E., Foss, D. A., Feoktistov, A. V., Vakhin, N. N., Petrukhina, and G. V., Romanov. 2017. Transformations of hydrocarbons of ashal'hinskoe heavy oil under catalytic aquathermolysis conditions. Petroleum Chemistry 57 (8):657–65. doi:10.1134/S0965544117050061.

[11] Kayukova, G. P., A. T., Gubaidullin, S. M., Petrov, G. V., Romanov, N. N., Petrukhina, and A. V., Vakhin. 2016. Changes of asphaltenes' structural phase characteristics in the process of conversion of heavy oil in the hydrothermal catalytic system. Energy & Fuels 30 (2):773–83. doi:10.1021/acs.energyfuels.5b01328.

[12] Khalil, M., R. L., Lee, and N., Liu. 2015. Hematite nanoparticles in aquathermolysis: A desulfurization study of thiophene. Fuel 145:214–20. doi:10.1016/J.FUEL.2014.12.047.

[13] Kondoh, H., K., Tanaka, Y., Nakasaka, T., Tago, and T., Masuda. 2016. Catalytic cracking of heavy oil over TiO2–ZrO2 catalysts under superheated steam conditions. Fuel 167:288–94. doi:10.1016/J.FUEL.2015.11.075.

[14] Lakhova, A., S., Petrov, D., Ibragimova, G., Kayukova, A., Safiulina, A., Shinkarev, and R., Okekwe. 2017. Aquathermolysis of heavy oil using nano oxides of metals. Journal of Petroleum Science and Engineering 153:385–90. doi:10.1016/J.PETROL.2017.02.015.

[15] Lei, Y., Y., Bin, and Z., Tao. 2017. Gasification of N-C7 asphaltenes using Ni-based catalysts. Petroleum Science and Technology 35 (24):2283–6. doi:10.1080/10916466.2017.1402033.

[16] Li, G.-R., Y., Chen, Y., An, and Y.-L., Chen. 2016. Catalytic aquathermolysis of super-heavy oil: Cleavage of CS bonds and separation of light organosulfurs. Fuel Processing Technology 153:94–100. doi:10.1016/J.FUPROC.2016.06.007.

[17] Lin, L., F., Zeng, and Y., Gu. 2014. A circular solvent chamber model for simulating the VAPEX heavy oil recovery process. Journal of Petroleum Science and Engineering 118:27–39. doi:10.1016/J.PETROL.2014.03.010.

[18] Liu, X., Y., Li, Z., Zhang, X., Li, M., Zhao, and C., Su. 2015. Synthesis of silica/metatitanic acid nanocomposite and evaluation of its catalytic performance for aquathermolysis reaction of extra-heavy crude oil. Journal of Energy Chemistry 24 (4):472–6. doi:10.1016/J.JECHEM.2015.06.005.

[19] Montgomery, W., R. W., Court, A. C., Rees, and M. A., Sephton. 2013. High temperature reactions of water with heavy oil and bitumen: Insights into aquathermolysis chemistry during steam-assisted recovery. Fuel 113:426–34. doi:10.1016/J.FUEL.2013.05.098.

[20] Muraza, O., and A., Galadima. 2015. Aquathermolysis of heavy oil: A review and perspective on catalyst development. Fuel 157:219–31. doi:10.1016/j.fuel.2015.04.065.

[21] Olvera, J. N. R., G. J., Gutiérrez, J. A. R., Serrano, A. M., Ovando, V. G., Febles, and L. D. B., Arceo. 2014. Use of unsupported, mechanically alloyed NiWMoC nanocatalyst to reduce the viscosity of aquathermolysis reaction of heavy oil. Catalysis Communications 43:131–5. doi:10.1016/J.CATCOM.2013.09.027.

[22] Petrov, S. M., D. A., Ibragimova, A. G., Safiulina, B., Tohidi Kalorazi, A. V., Vakhin, R. C., Okekwe, and E. A., Karalin. 2017. Conversion of organic matter in the carbonaceous medium in the supercritical water. Journal of Petroleum Science and Engineering 159:497. doi:10.1016/j.petrol.2017.09.060.

[23] Srochviksit, S., and K., Maneeintr. 2016. Simulation on heavy oil production from steam-flooding. In MATEC web of conferences, ed. A. J., Arumugham, M. M., Ulkhaq, M., Kocisko, R. K., Goyal, W. A., Yusmawiza, and X., Qiu, 1–4. France: EDP Sciences.

[24] Tumanyan, B. P., N. N., Petrukhina, G. P., Kayukova, D. K., Nurgaliev, L. E., Foss, and G. V., Romanov. 2015. Aquathermolysis of crude oils and natural bitumen: Chemistry, catalysts and prospects for industrial implementation. Russian Chemical Reviews 84 (11):1145–75. doi:10.1070/RCR4500.

[25] Vakhin, A. V., S. A., Sitnov, I. I., Mukhamatdinov, Y. V., Onishchenko, and D. A., Feoktistov. 2017. Aquathermolysis of high-viscosity oil in the presence of an oil-soluble iron-based catalyst. Chemistry and Technology of Fuels and Oils 53 (5):666–74. doi:10.1007/s10553-017-0848-9.